



Electron cloud clearing in SNS

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Thanks:

*J. Wei, M. Blaskiewicz, A. Fedotov, P. He., Y.Y. Lee,
D. Raparia, T. S. Wang, S.Y. Zhang, R. Macek, K. Ohmi,
Fukuma, A. Chao, F. Zimmermann,...*

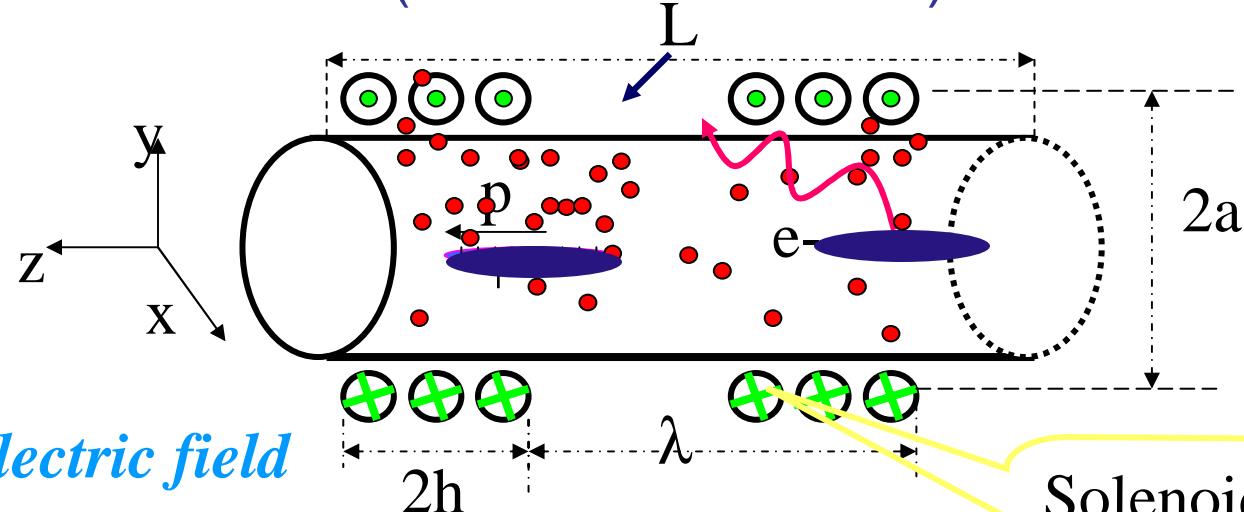
3D PIC Program--- CLOUDLAND



CLOUDLAND is a complete 3D PIC code for e-cloud initially developed for KEKB (**PRST-AB 124402**)

Program model

- ◆ PIC methods



Magnetic and electric field

- ◆ General 3-dimensional fields given by expression.
- ◆ Fields can also be import from other program using table

Beam potential

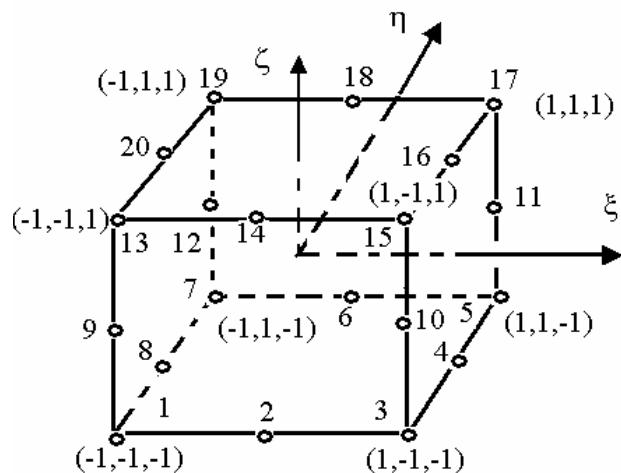
- ◆ Gaussian bunch in round chamber (image charge is included)
- ◆ PIC method for general geometry

Secondary emission and reflective electron are included

Particle Mesh technique applied in the Space charge potential solver



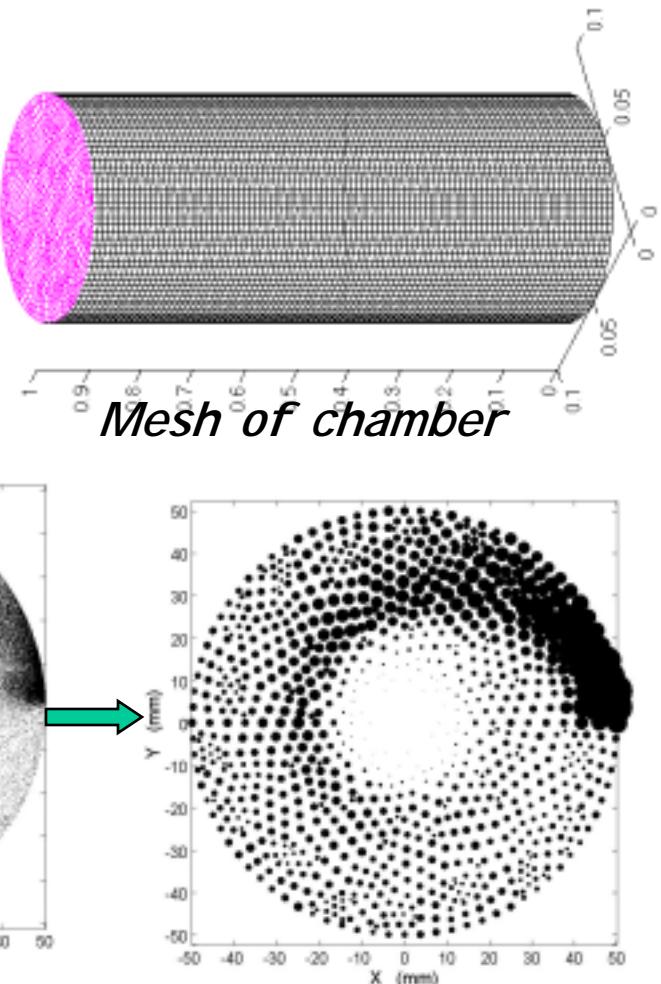
- Three dimensional irregular mesh to better represent the general chamber geometry
- handle accuracy with high order elements.



Charge assignment

$$Q_i = N_i Q_0 \quad \sum_i N_i = 1$$

Real charge distribution

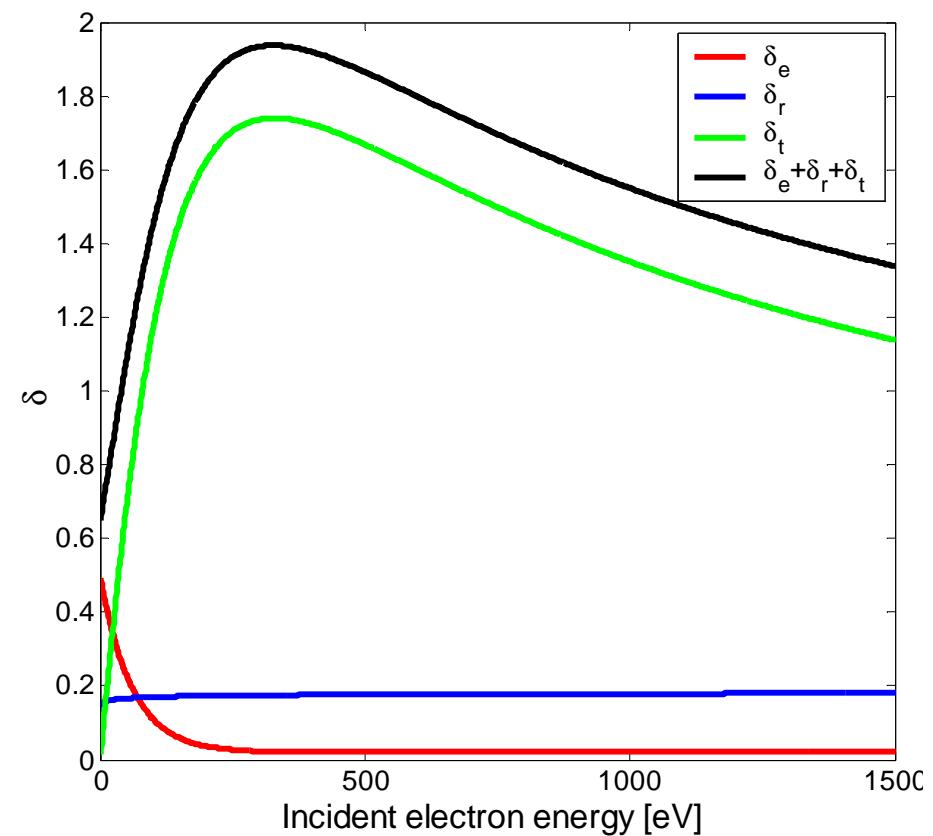


Meshed Charge distribution

SEY parameters



Backscattered electrons	
$P_{1,e}(\infty)$	0.02
$\hat{P}_{1,e}$	0.5
$\hat{E}_e(eV)$	0
$W(eV)$	60
P	1
Re-diffused electrons	
$P_{1,r}(\infty)$	0.19
$\hat{E}_r(eV)$	0.041
R	0.104
True secondary electrons	
$\hat{E}_{ts}(eV)$	330
$\hat{\delta}_{ts}$	1.74
S	1.52553



Main parameters of SEY

Secondary emission yield

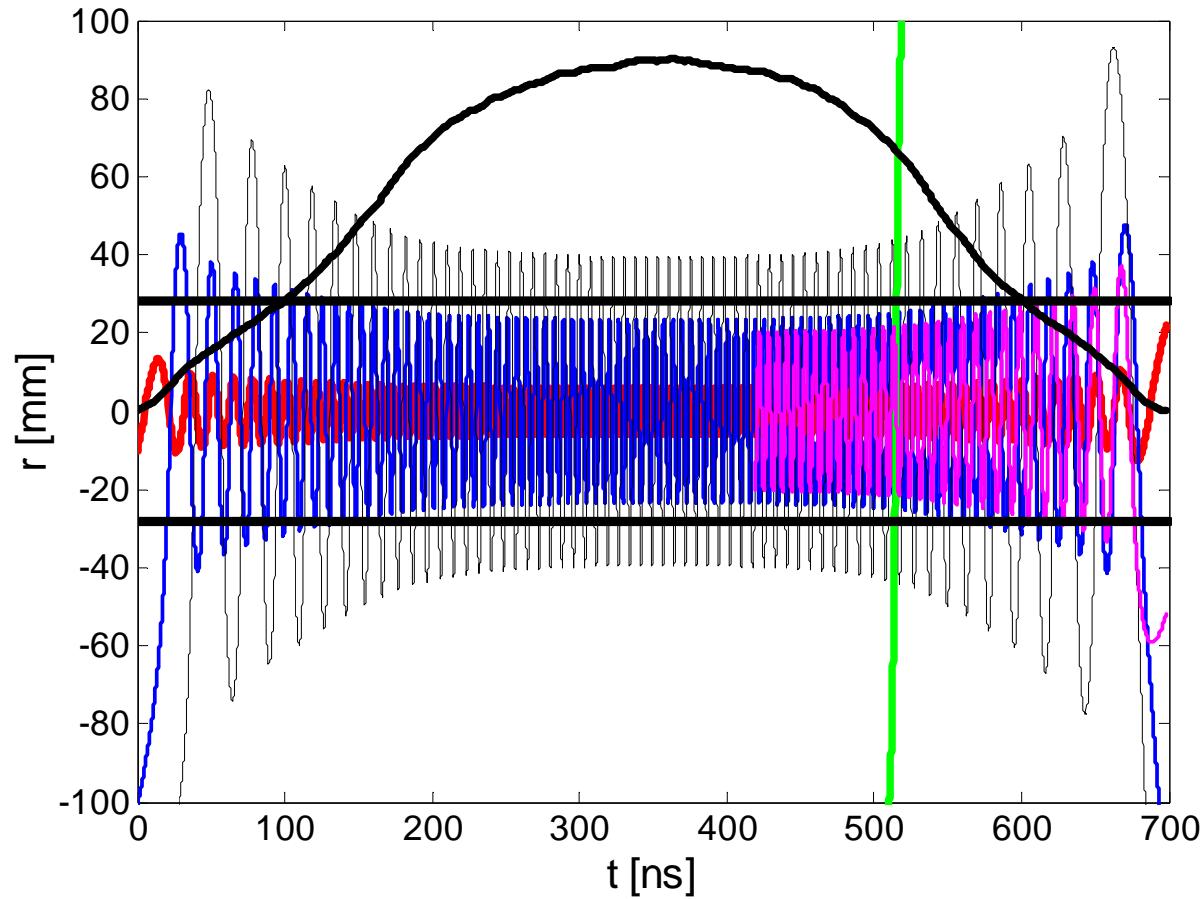
Ecloud in SNS



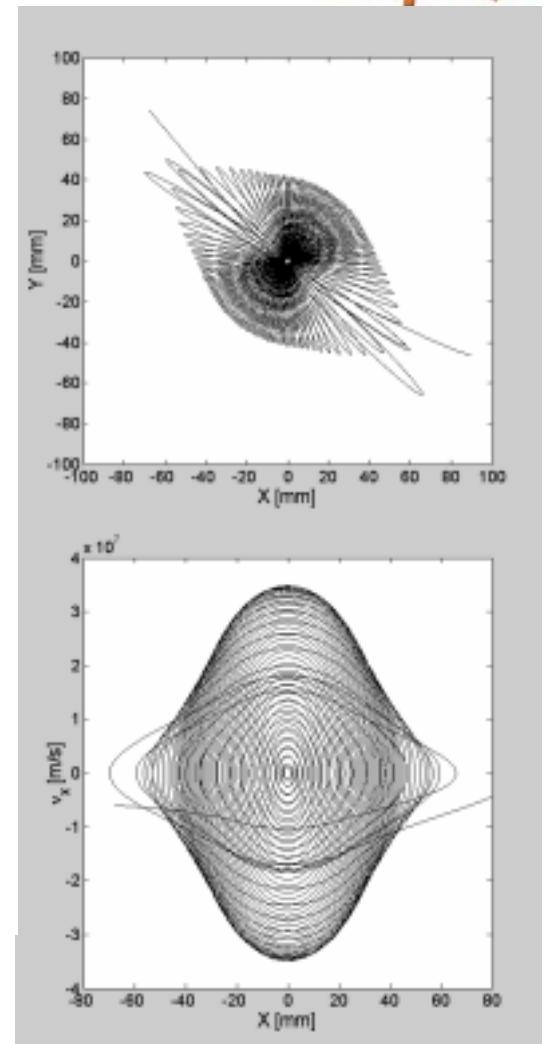
Table 1 Simulation parameters for the SNS

Parameter	Description	SNS
E (GeV)	Beam energy	1.9
C (m)	Circumference	248
N_p	Bunch population	2.05×10^{14}
a_x, a_y (mm)	Transverse beam size	28, 28
τ_b (ns)	Bunch length	700
b (cm)	Beam pipe radius	10
P_l	Proton loss rate	1.1×10^{-6}
Y	Assumed proton-electron yield	100

Particle motion--→"trailing edge multipactor"

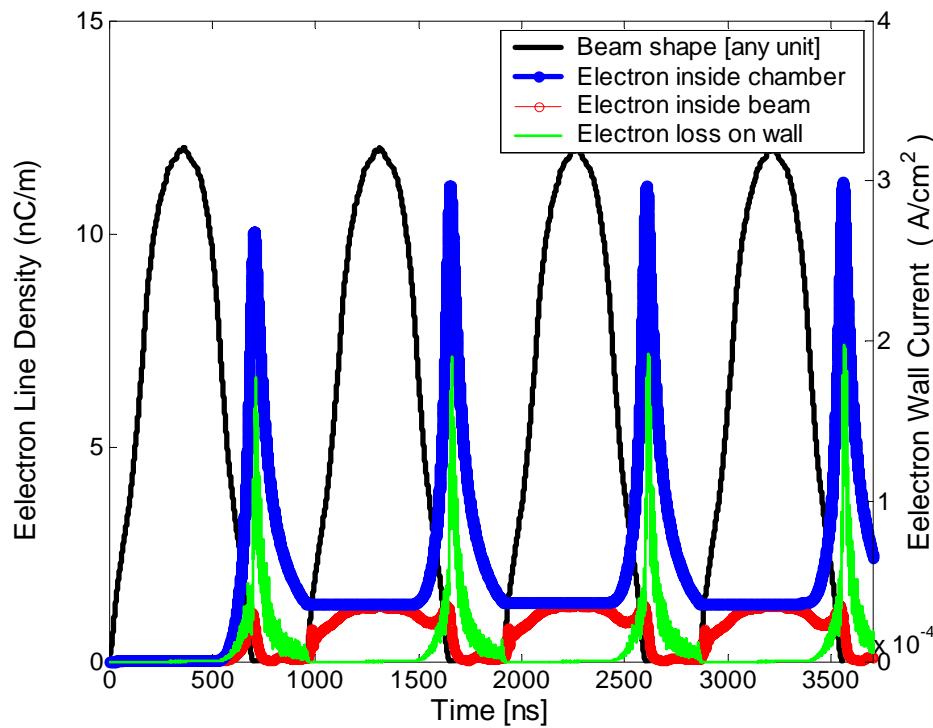


Coasting beam is more difficult to trap electron than bunch beam.

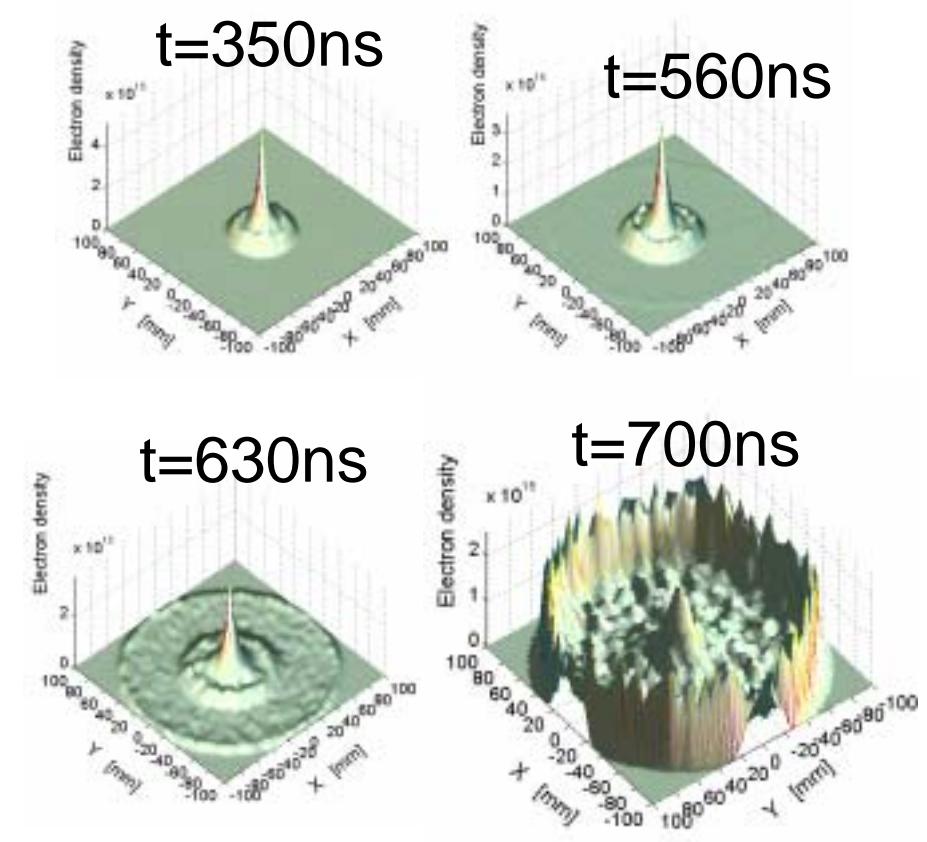


Phase plot of trapped e-

E-cloud in drift region



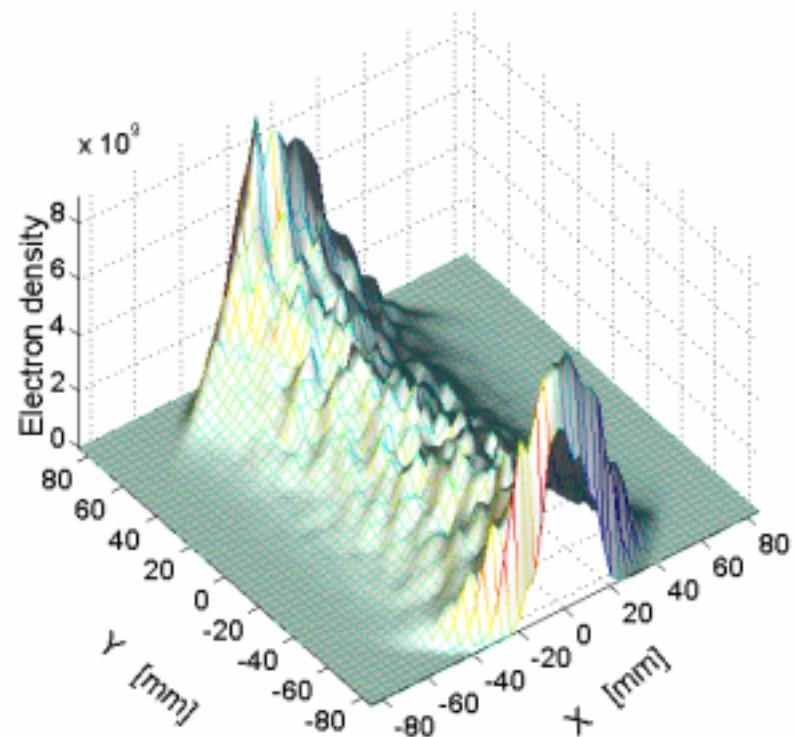
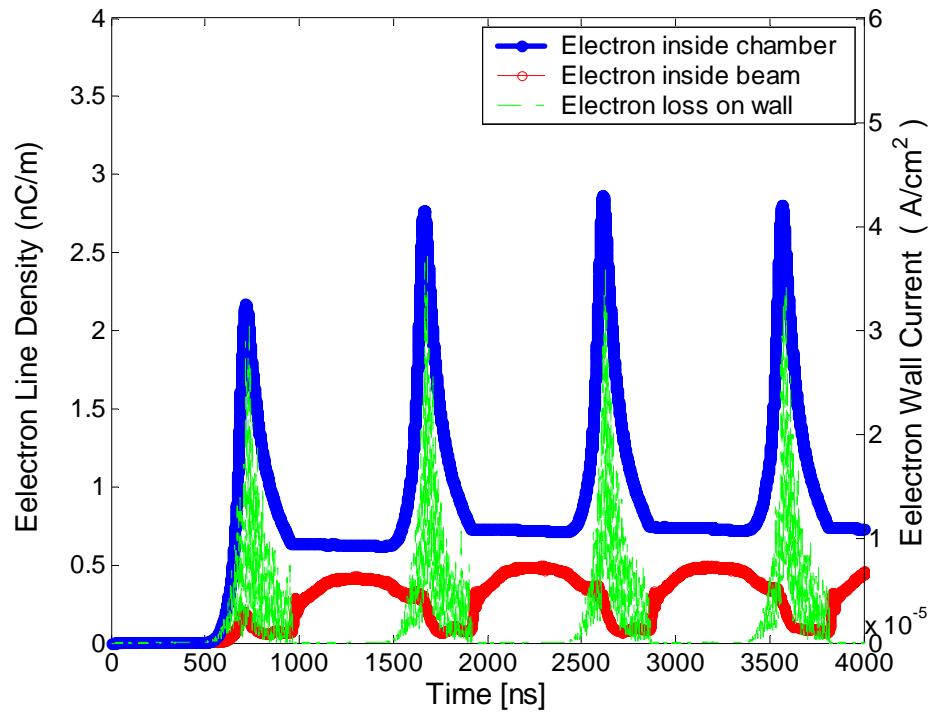
E-cloud build-up in SNS drift region



E-cloud distribution in different time

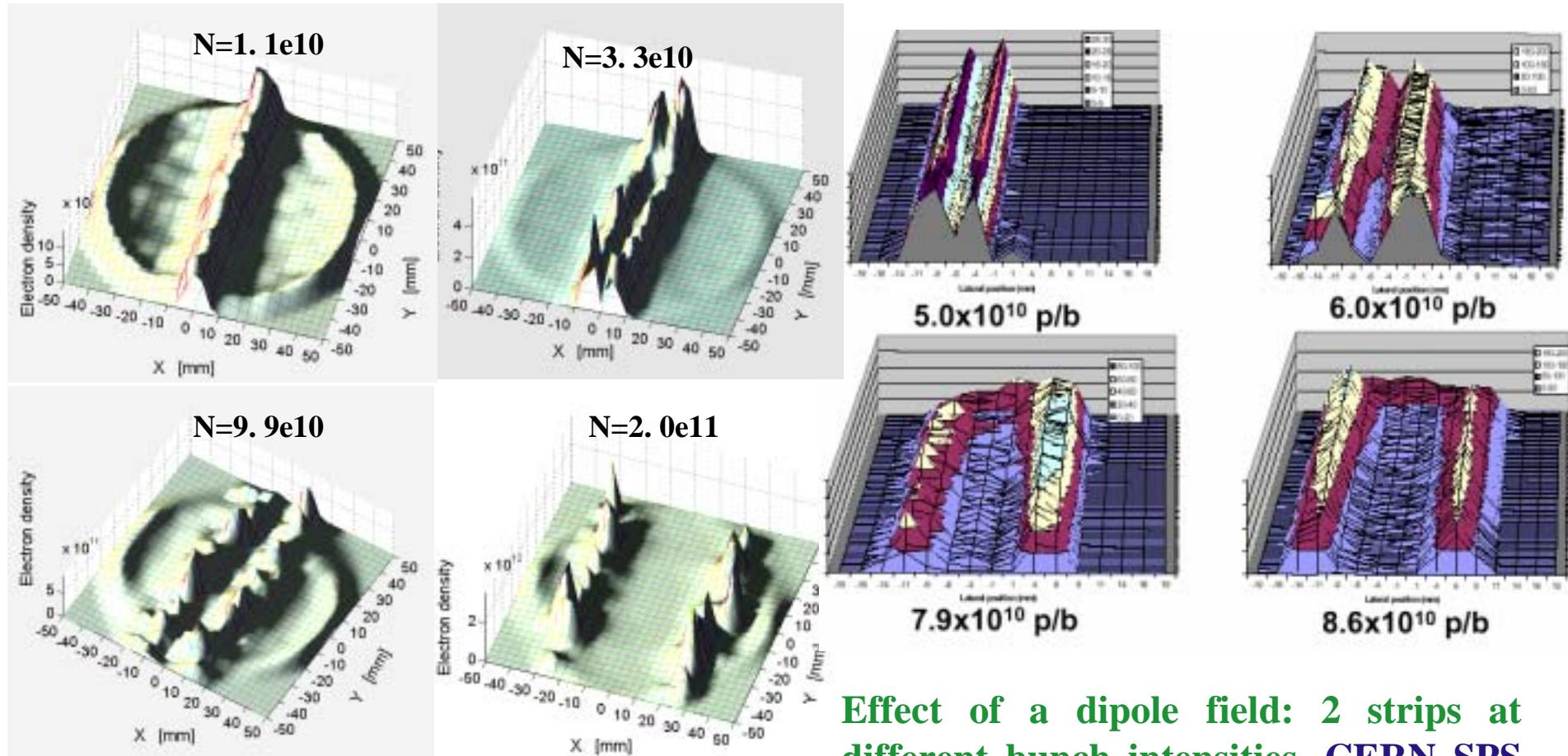
All electrons survived from last bunch gap can be trapped inside beam around bunch center, bunch gap is very important

E-cloud in Dipole magnets



- Multipacting happen at the horizontal chamber center
- E-cloud is about 2 times smaller than drift region

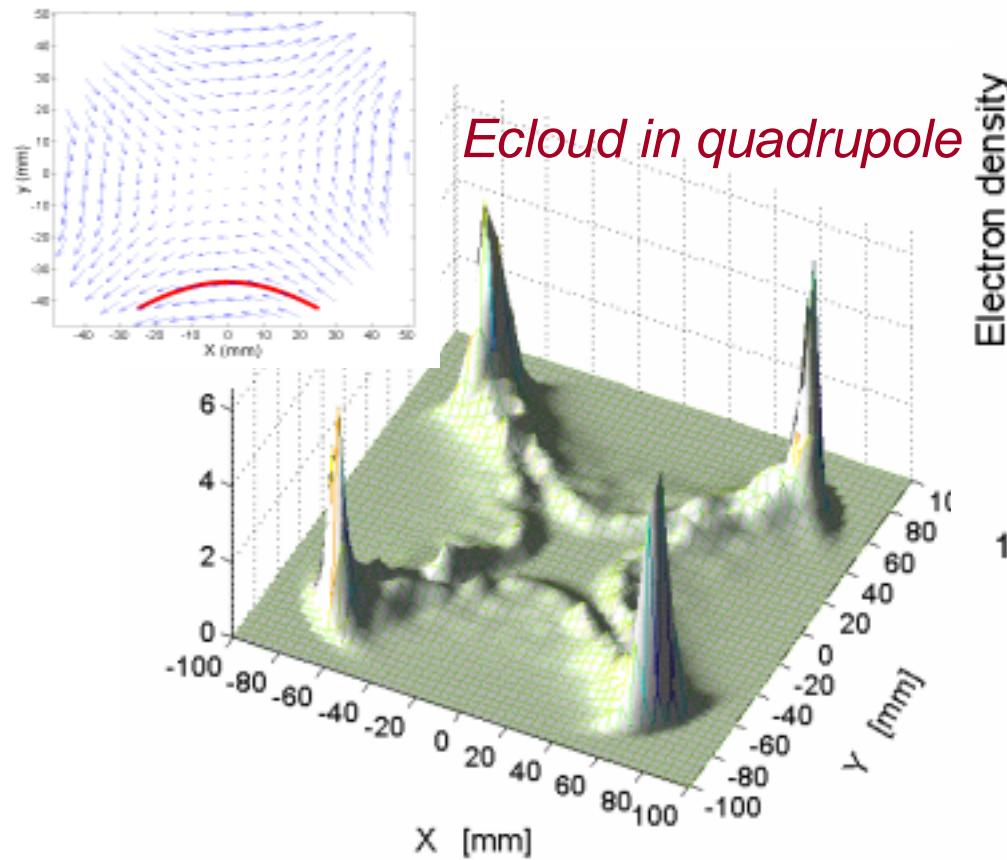
Bunch current effects on Multipacting in *dipole---short bunch ---strip position and lost charge density*



KEKB LER, simulation

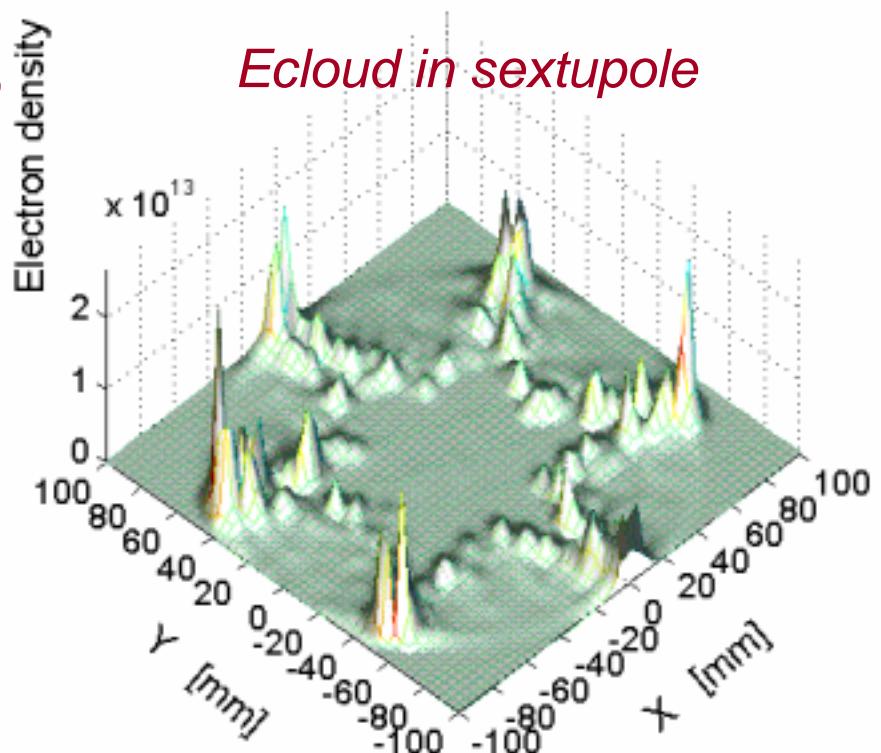
Effect of a dipole field: 2 strips at different bunch intensities, CERN SPS experimental results, J. M.Jimenez, ECloudí02, CERN, 2002

E-cloud in Quadrupole and sextupole magnets



Ecloud in quadrupole

Electron density



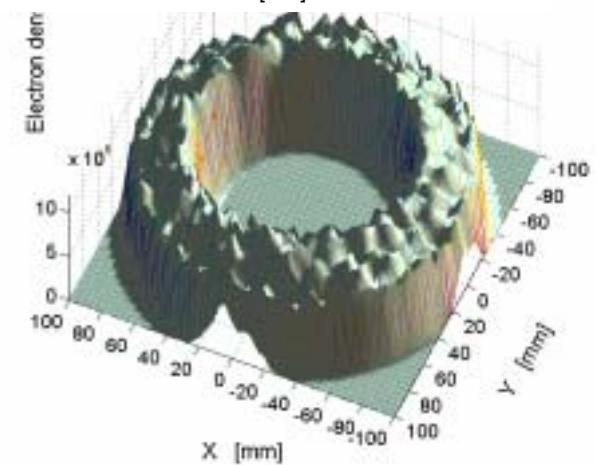
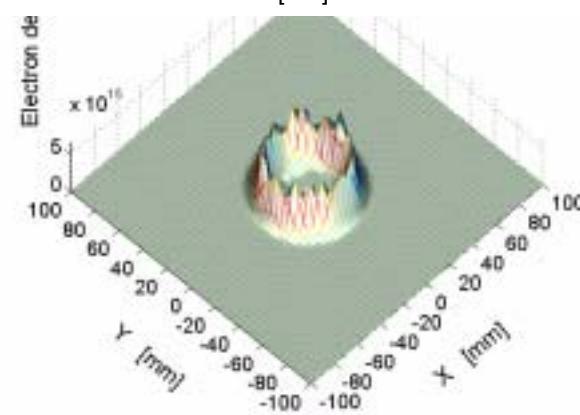
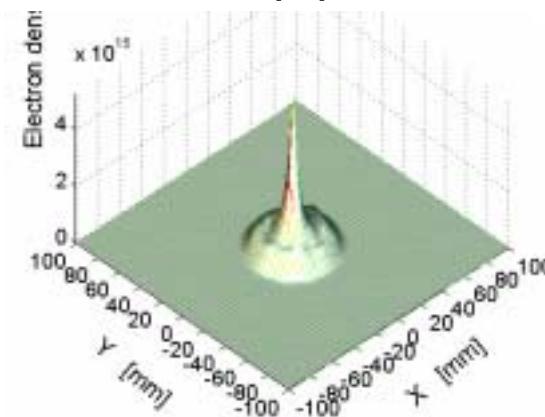
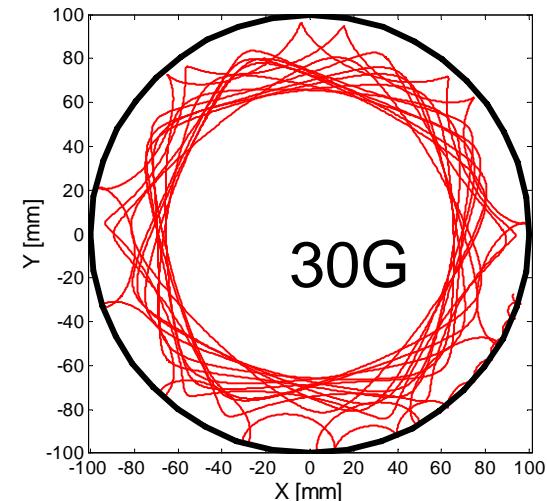
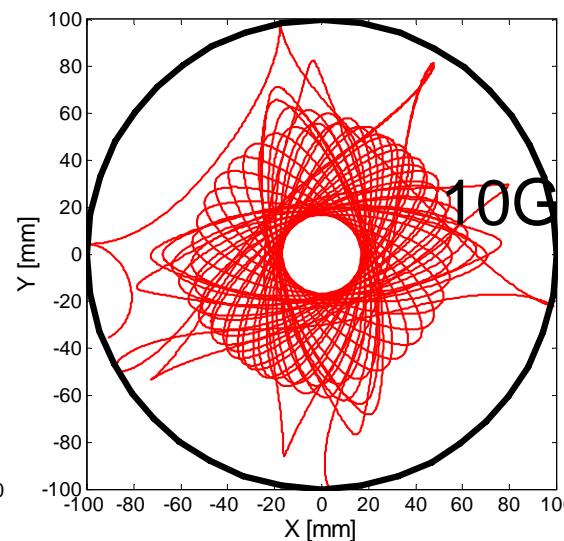
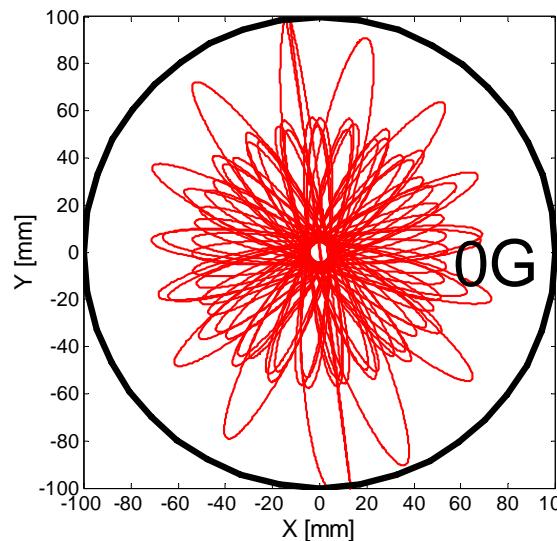
Ecloud in sextupole

- Weak multipacting happens only near the middle of the pole surface
- No Trapping for long bunch! (Trapping condition: Bunch length should be shorter than period of gyration motion around the mirror points, ref. PRE 66-036502, 2002)

Solenoid effects



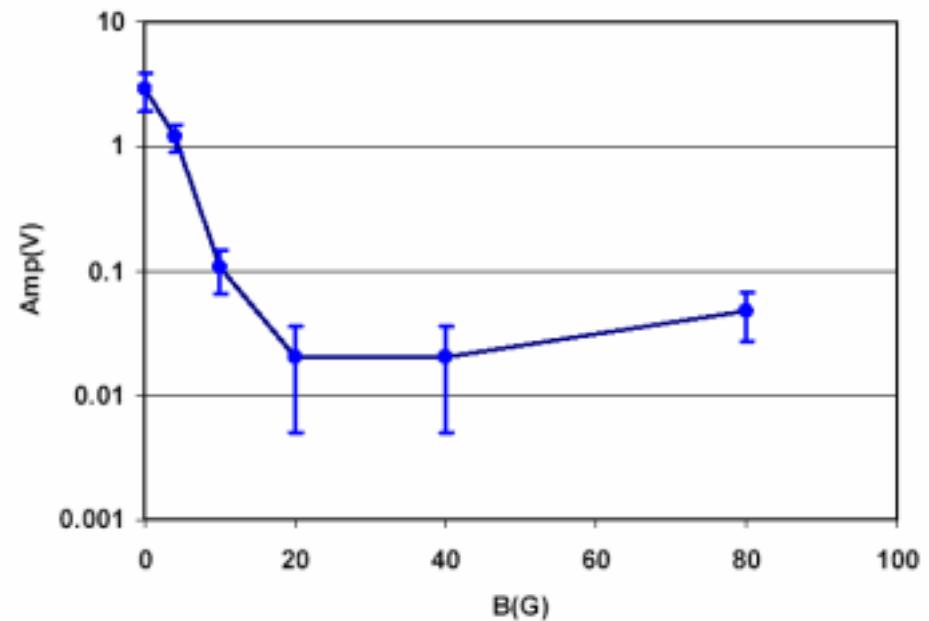
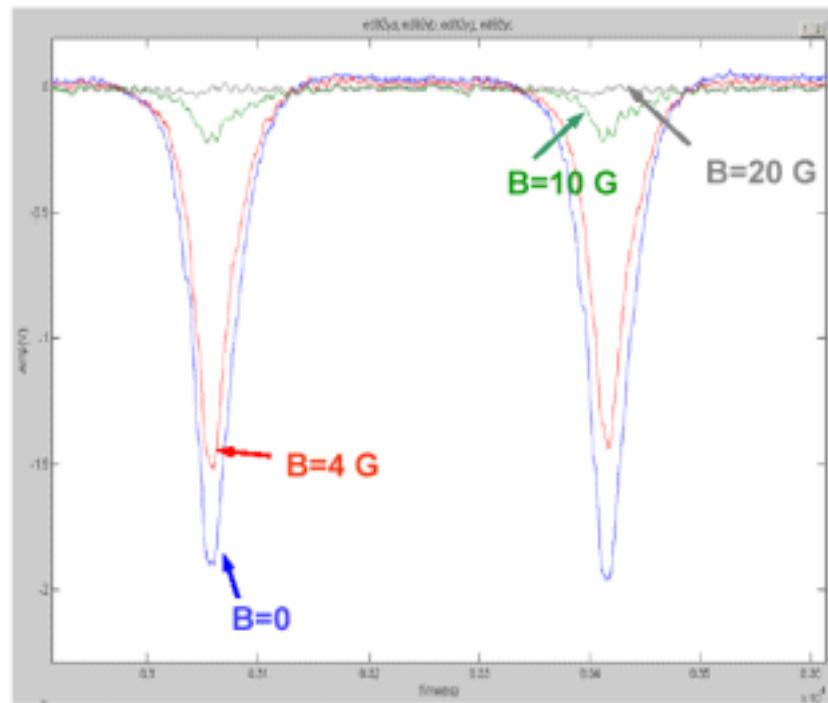
- 30G Solenoid field can reduce the e-cloud density with a factor 2000 !
- Zero density within beam



PSR experiment (ecloud02, Macek)

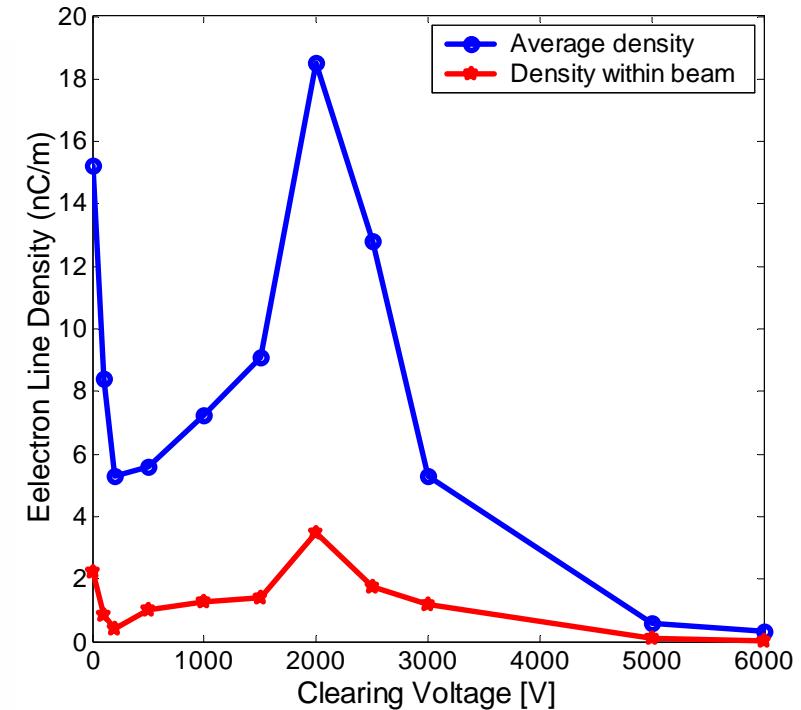
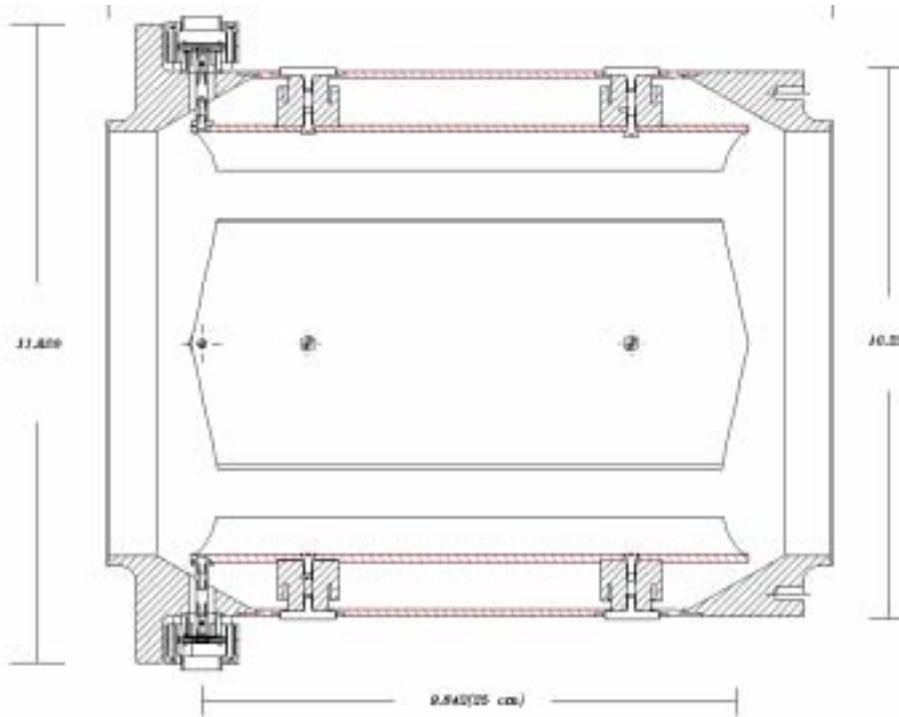


RFA signals in a weak solenoid fields



20G B field can reduce the electron signal by a factor 100

Electrode clearing effect vs Clearing voltage (SNS Tech note 128)



e-cloud density vs clearing fields

- Weak field(~200V) is very helpful
- Strong multipacting at 12kV, which could be stronger than zero field case

PSR(PSR-94-03, M. Plum, etc.)

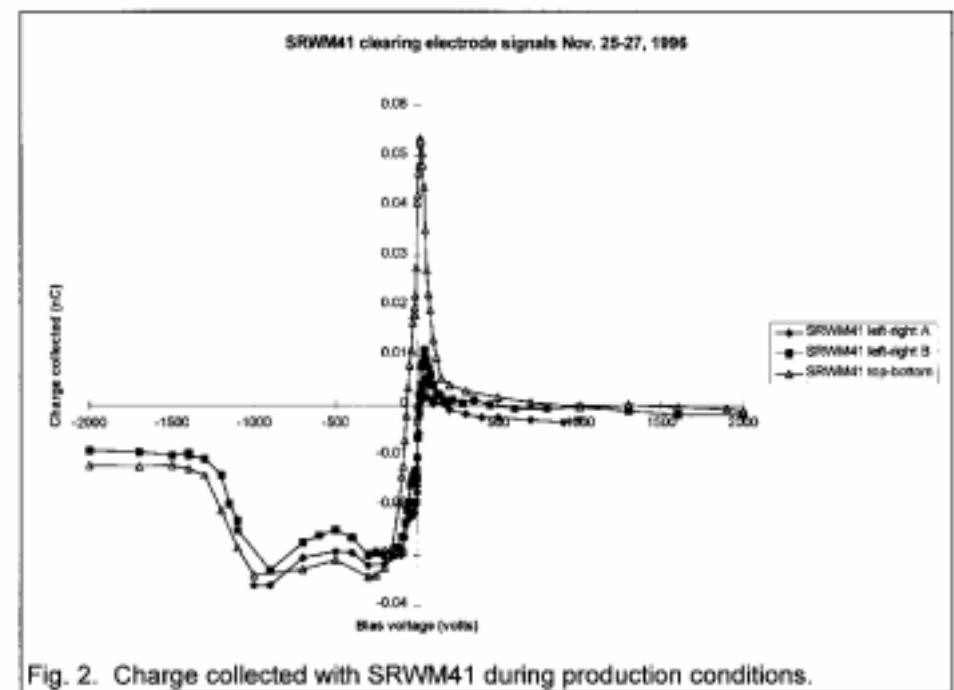
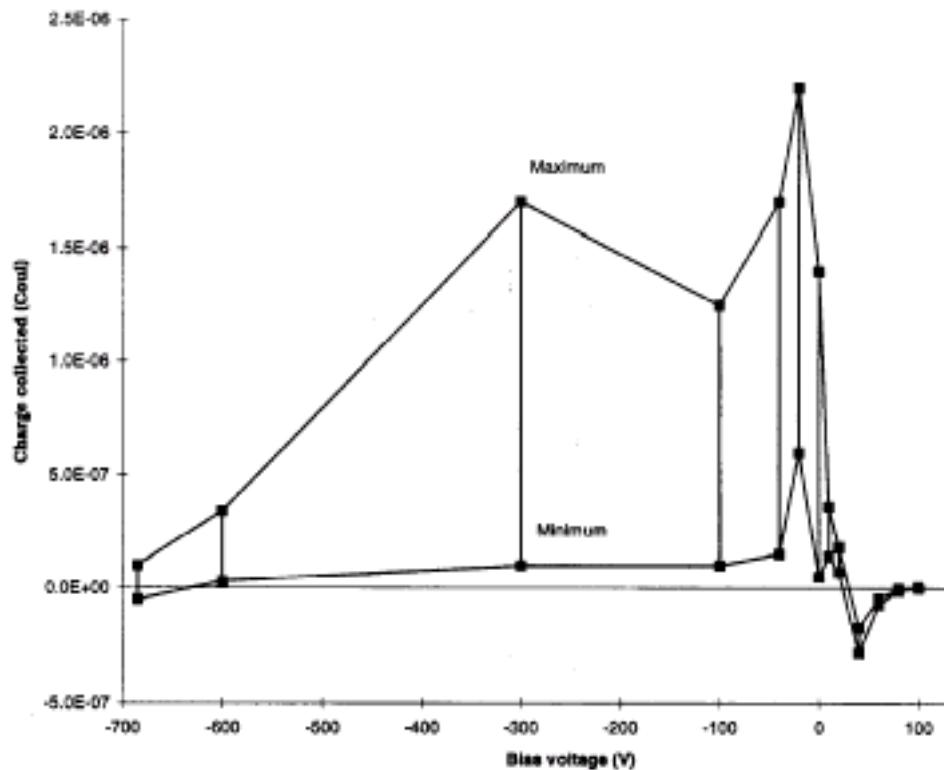
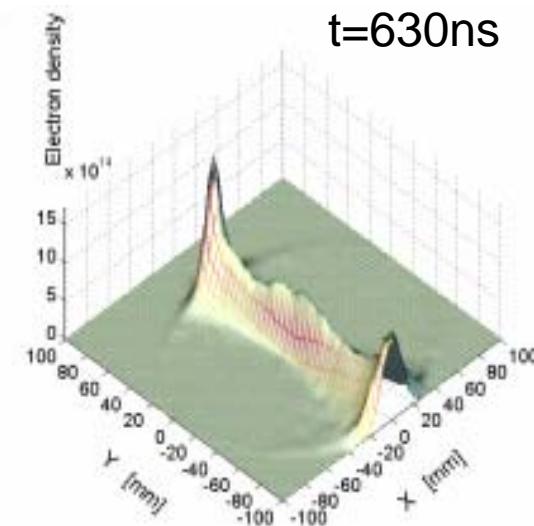
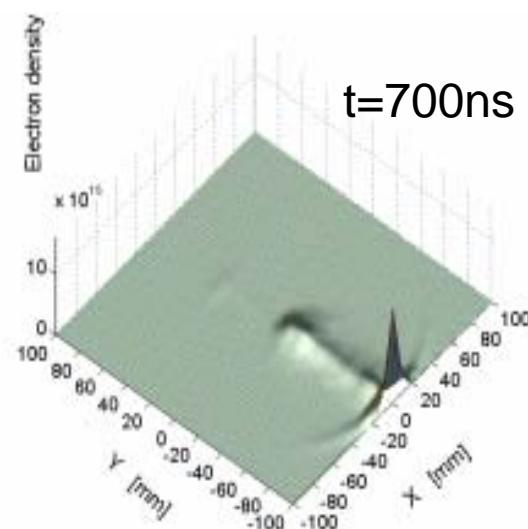
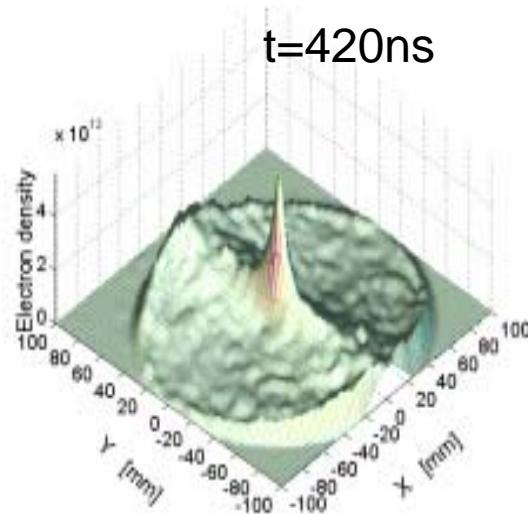


Fig. 2. Charge collected with SRWM41 during production conditions.

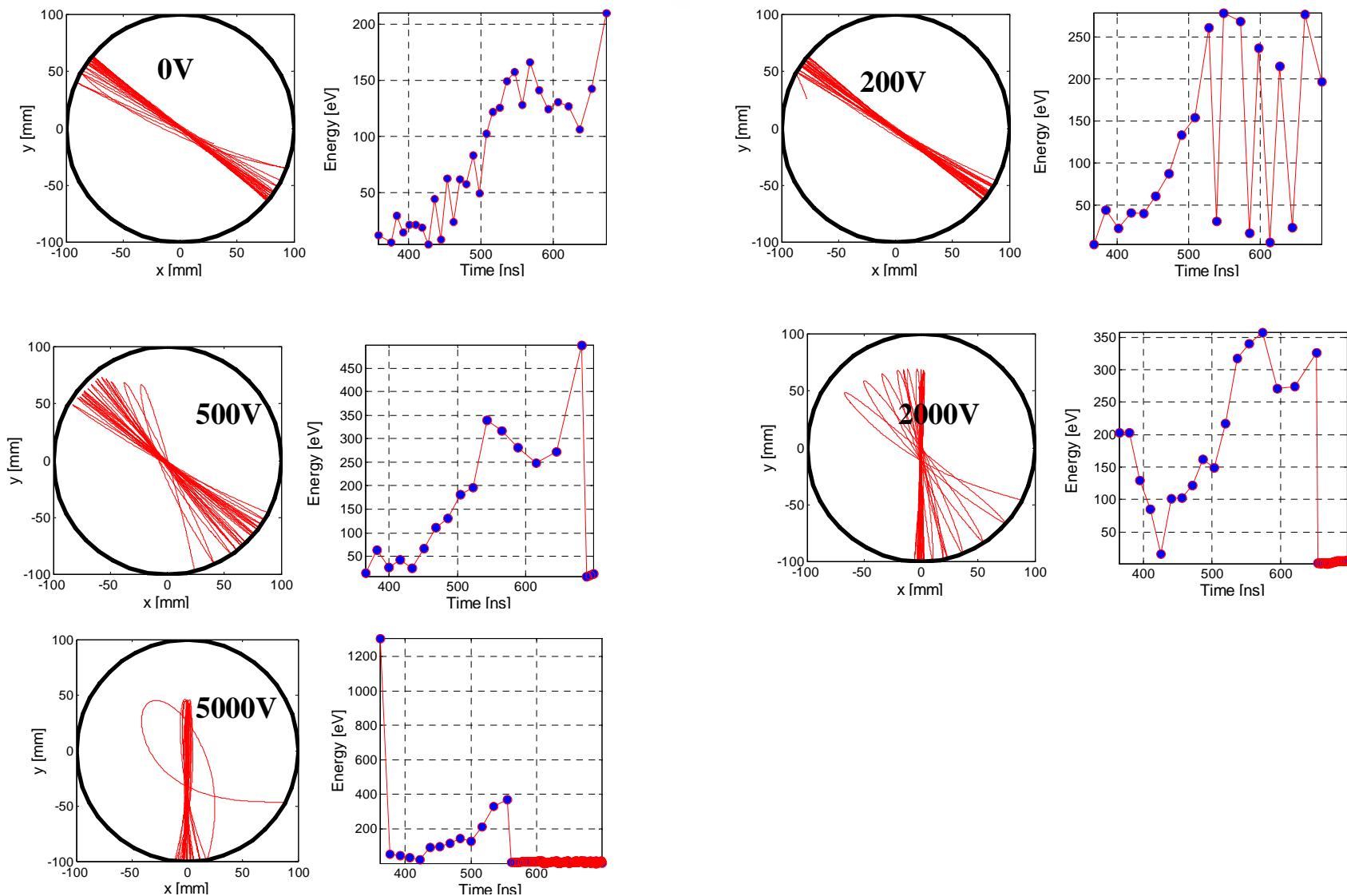
PSR Experimental result

E-cloud distribution at different time for 500V clearing field



➤ Clearing field can cause the particle polarized toward the clearing field direction. As a result, it causes strong multipacting near the positive electrode.

Mechanism of strong multipacting due to clearing field



Summary



- Strong trailing edge multipacting in drift region
- Multipacting happen at the **chamber center** in dipole magnet
- There is **weak multipacting** in quadrupole and sextupole magnet, where the electron density is one order lower than drift region
- There is **no trapping** in quadrupole magnet for the **long proton beam**.
- Weak solenoid with field up to **30 Gauss** can effectively suppress electron cloud in drift region.
- Clearing **electrode** also **works** but has **complicate effect** which depends on the clearing field